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The purpose of the experimentation is to explore the difference between immediate and delayed reinforcement. It is stated that the relative effectiveness of either reinforcement depends on the type of response learned and the function of the reinforcement. These experiments explored the interaction between the time interval separating response and reinforcement, the different types of learning material, and the different reinforcement functions.

The four experiments used are 1) factual material, 2) nonsense material, 3) material requiring inductive generalization with reinforcement in the form of the correct answer, 4) material requiring inductive generalization with reinforcement in the form of a cue directing the subject to the correct answer.

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# TO REINFORCE THE LEARNER

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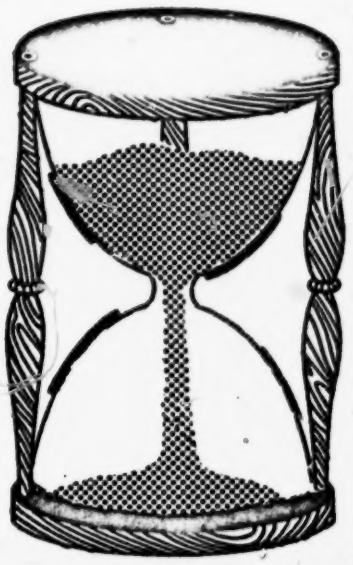

**Later ?**

*Louis Bruno*
*Superintendent of Public Instruction*
*Olympia*

# THE RELATIVE EFFECTIVENESS OF IMMEDIATE AND DELAYED REINFORCEMENT ON LEARNING ACADEMIC MATERIAL

By

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Research Report No. 05-02

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Ray E. Jongeward
Director of Research
Office of State Superintendent of Public Instruction
Olympia, Washington

April 1964

CENTRAL WASHINGTON STATE COLLEGE | ELLENSBURG, WASHINGTON
98926

March 31, 1964

Mr. Louis Bruno
State Superintendent of Public Instruction
Olympia, Washington

Dear Mr. Bruno:

I am pleased to report to you that the study conducted by Dr. Sturges and Dr. Crawford of this college, under a research grant from the State Office of Public Instruction, has now been finished.

As the first state-supported research project on this campus, the completion of this particular study is a positive step forward for us. We hope that this study will stimulate more activity along research lines and that we qualify for other grants in the future.

The study itself, "The Relative Effectiveness of Immediate and Delayed Reinforcement on Learning Academic Material," has drawn much attention from other colleges and universities. I believe it is the type of project that can be of much benefit to education. I hope its results can be applied in our classrooms.

I want to express my thanks to you and your staff, and Dr. Jongeward in particular, for the help and encouragement that has been given, not only on this project but in many other endeavors. We look forward to continuing these fine working relationships.

Sincerely yours,

James E. Brooks

James E. Brooks
President

JEB:mp

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## INTRODUCTION

The following experiments are concerned with the applicability of an almost universally held assumption: that learning is facilitated when a reinforcement promptly follows a response. The view that learning varies inversely with the amount of time intervening between a response and reinforcement is incorporated in several prominent theoretical approaches to learning (Hull, 1952; Spence, 1956; Miller, 1950; Skinner, 1938, 1957). Furthermore, this notion of the superiority of immediate reinforcement has been included in almost all attempts to apply principles of learning to education practices. Current textbooks in educational psychology often cite this as a fundamental principle of learning. Klausmeier (1960) states

> Reinforcement immediately following the correct response usually facilitates learning more than does a delayed reward or reinforcement. The teacher must know what the correct responses are and observe and reinforce them immediately. The greatest possibility for the improvement of all human abilities seems to lie at this point...

Blair, Jones, and Simpson (1962) suggest "From what is presently known, feedback is most effective if immediate and specific." Bigge and Hunt (1962) state "The key to effective teaching of thinking, as any other behavior, is immediate feedback." Similar claims for the superiority of immediate reinforcement in classroom learning can be found in almost any modern textbook of educational psychology.

The booming expansion of teaching machines has further emphasized this principle. All current programs for teaching machines appear to be based on the notion that immediate reinforcement is the most effective condition for learning. Holland (1960), co-worker of Skinner and a key figure in the development of teaching machine programs, suggests that of several well-known learning principles to be applied to teaching machine development, "immediate reinforcement for correct answer is a must. . ." Similar authoritative assertions, proclaiming the necessity of immediate reinforcement,

are found throughout the literature pertaining to teaching machines and programming. In teaching machine programs and in programed tests as well, the reinforcement consists of either informing the student of the correct answer or telling him whether his answer was right or wrong.

Although this new medium focuses attention upon the importance of immediate reinforcement, its application is not limited to programed learning. Broadly conceived, reinforcement is any consequence following a response which results in increased likelihood of that response in the future. Thus, telling a student that his answer is right or wrong, handing back tests, assigning grades, the teacher's approval of any student behavior are all examples of reinforcement. Much of the teacher's behavior may be considered as the application of reinforcement. Consequently, valid principles of reinforcement have broad applicability to educational practice. Therefore, it is crucial that any asserted principles be validated upon relevant human learning problems. If the principle of the superiority of immediate reinforcement is tenuously founded or even erroneous when applied to typical classroom learning, educational progress may be seriously retarded.

Empirical evidence for the principle of immediate reinforcement has been derived from three types of studies:

A) animal experiments
B) studies of human motor skills
C) experiments using typical classroom material

Evidence for the superiority of immediate reinforcement is most conclusive in studies of motor responses in lower animals. The animal, ordinarily a rat or a pigeon, has been deprived of food for 12 to 24 hours, and food is used as the reinforcement. There is some question as to the applicability of results derived from such animal studies to the learning of academic material by humans. It is a long inferential

step from a rat learning to press a bar to a human learning principles of integral calculus. Food and "knowledge of results" represent marked differences in types of reinforcement. As far as the type of response is concerned, the most analogous learning situation for humans would be one of motor skills.

Empirical evidence on the effect of delay of reinforcement, in the form of knowledge of results, upon human motor skills questions the superiority of immediate reinforcement. Several studies (Lorge & Thorndike, 1935; Saltzman, Kanfer, & Greenspoon, 1955; Noble and Alcock, 1958; Denny, et al, 1960; Ryan, 1959) have found no difference between immediate and delayed reinforcement on such responses as drawing lines, moving a bar, pulling a lever, etc. In one study (Bilodeau & Bilodeau, 1958) delay showed a superiority in one of five experiments while no significant difference was found in the other four studies. In their review of the effect of delay of reinforcement upon motor skills learning, Bilodeau & Bilodeau (1961) conclude that "immediate knowledge of results is immaterial to learning so long as the time intervals are free from specially interpolated responses."

Relatively few experiments have investigated the effect of immediate versus delayed reinforcement using typical classroom material. These studies (Angell, 1949; Little, 1934; and Pressey, 1950) indicate superior learning under conditions of immediate reinforcement. However, in each of these studies the method of administering reinforcement differed between the immediate and delayed group. Ordinarily, the immediate group received feedback by a punchboard device and the delayed group by the usual marking of errors on objective test items. Thus, any effect may be due to any of the following:

a) temporal interval between response and reinforcement
b) type of reinforcement
c) an interaction between the temporal interval and the type of reinforcement.

No clearcut interpretation of the results of such studies is possible. Furthermore, the novelty effect of new teaching devices is a possible source of confounding. An adequate test of immediate reinforcement requires that both groups should receive the same form of presentation of material and the same form of reinforcement.

Hypotheses

The general hypothesis under which the present series of experiments were designed is that whether immediate or delayed reinforcement is more effective depends upon two factors: 1) the type of response the subject is to learn; and 2) the relative compatibility of what the reinforcer causes the subject to do with the response to be learned.

For example, when classroom learning is concerned with meaningful verbal behavior, the desired response is probably some form of relevant symbolic exploration of the material. If conditions are conducive for the learner to indulge in symbolic mediated activity during the interval between the response on record and the reinforcement, a delay of reinforcement may facilitate learning. This would be particularly the case if the reinforcement itself tends to interrupt or preclude further relevant symbolic behavior. The above example contrasts with the learning of simple bar-pressing responses, motor skills, or the use of subjects from a lower species or those with a scant symbolic repertoire. In the latter cases little facilitating effect could be expected from any mediating activity between response and reinforcement.

The function of reinforcement in the classroom where it is usually in the form of knowledge of results would seem to differ considerably from the function served by food for the hungry animal. Reinforcement may serve any or all of a number of different functions: for example, a satisfier, a motivator, partial or complete information about the correctness of the response, etc. The effect of these different functions of reinforcement upon symbolic activity seems likely to vary considerably. For example,

a partial cue to the solution of a mathematics problem may produce more subsequent symbolic activity than a "satisfier," such as "that's good" or food. On the other hand, complete information may well bring any symbolic activity to a halt. Thus, the respective advantage of either immediate or delayed reinforcement may depend on the degree to which the reinforcer promotes or retards pertinent symbolic behavior.

It follows from the above considerations that the relative effectiveness of immediate or delayed reinforcement depends on the type of response learned and the function of the reinforcement. The present series of experiments was designed to explore the interaction between the temporal interval separating response and reinforcement, differing types of learning material, and differing reinforcement functions.

Specific hypotheses were as follows:

A. When reinforcement is in the form of information indicating the correct answer:

1. Using typical discrete verbal material of a factual sort, for example, questions from test manuals in the social sciences, there will be no superiority of delayed over immediate reinforcement.

2. Using verbal material which mitigates against relevant symbolic activity, i.e., nonsense material, immediate reinforcement will be superior to delayed reinforcement.

3. Using meaningful verbal material designed to promote relevant symbolic activity, i.e., meaningful material from which the subject is to draw an inductive generalization, delayed reinforcement will be superior to immediate reinforcement.

B. When reinforcement is in the form of partial information, or a cue which directs the subject toward the correct answer <u>if</u> he then performs certain covert responses:

4. Then the relative superiority of delayed reinforcement predicted in hypothesis (3) would be overcome.

## METHOD AND PROCEDURE

Timing of reinforcement, or the temporal interval between response and reinforcement, was the major variable that the following four experiments were designed to explore. However, two other factors were also varied: (1) the type of learning material; and (2) the type of reinforcement. Thus, the four following experiments compared the relative effectiveness of immediate versus delayed reinforcement upon different types of learning material and differing kinds of reinforcement, as follows:

Experiment I: Factual material, with reinforcement in the form of the correct answer.

Experiment II: Nonsense material, with reinforcement in the form of the correct answer.

Experiment III: Material requiring an inductive generalization, with reinforcement in the form of the correct answer.

Experiment IV: Material requiring an inductive generalization, with reinforcement in the form of a cue directing the subject toward the correct answer.

### Subjects

In each of the four experiments subjects were undergraduate psychology students. They were randomly assigned by classes to the three experimental groups as follows:

Group A. Intermediate Reinforcement Group: reinforcement was given immediately after answering each question.

Group B. Delayed Reinforcement Group: reinforcement was delayed 24 hours.

Group C. Control Group: no reinforcement was given.

Three separate groups of subjects--Group A, Immediate; Group B, Delayed; and Group C, Control--were assigned to each of the four experiments.

## Apparatus

A 2" x 2" slide projector was used to present the material. Learning material consisted of multiple-choice questions, photographed and made into 2" x 2" slides. The specific learning material for each experiment will be described below. The original order of the slides was randomly assigned. In the feedback, or reinforcement, session the questions were presented in the original order. In the test session, slides were in a different order, again randomly assigned.

## Reinforcement

In each of the four experiments, reinforcement consisted of information relative to the correct answer. In Experiments I, II, and III, reinforcement consisted of the original question, the four alternatives with the correct answer marked, each presented on a 2" x 2" slide. In Experiment IV, reinforcement was in the form of a cue directing the subject to the correct answer. In this experiment feedback, or reinforcement, was presented by projecting two 2" x 2" slides simultaneously: one slide contained the original material and four alternatives; the other contained the cue, or reinforcement. In each experiment the manner of presenting the reinforcement was the same for both Immediate Reinforcement and Delayed Reinforcement groups.

## PROCEDURE

### General Procedure for the Four Experiments

The general experimental procedure was essentially the same for each of the four experiments. Subjects were presented with learning material consisting of multiple-choice questions and recorded their answers immediately after seeing each question. They then received either immediate, delayed or no reinforcement. All subjects were tested on the original learning material one week later. The four experiments differed procedurally in minor ways which will be described later.

For each of the four experiments the experimental sessions occurred during the subjects' regular class periods. For Group B, Delayed Reinforcement, and Group C, Control Group, there were three experimental sessions: Session 1, original presentation of the material; Session 2, 24 hours later; and Session 3, the test session one week after Session 1. Group A had only the first and third experimental sessions. However, in each experiment the number of presentations of the material, the type of presentation of the material, and the length of exposure of the material was equated for all three groups. For each of the four experiments the specific procedure for each experimental session was as follows:

1st Session. On the first day of the experiment each group was told that they were to participate in a study concerned with the effectiveness of different ways of presenting materials. They were instructed that they would be shown questions, one at a time, that while the slide was exposed they were to think about the question and the answer, when the slide disappeared they were to write the letter of their choice of answer on sheets of paper provided, and then turn their answer over. They were further instructed that most of the questions were on material unfamiliar to them, but not to worry if they did not know the answer, and that their performance would not

affect their grade in the course. Ss in Group A were also told that after answering each question they would then be given feedback relative to the correct answer.

For the first experimental session the procedure for each slide was as follows: Ss in Group A (Immediate Reinforcement Group) were presented with the multiple-choice question; they then wrote the choice of their answer and turned the answer over; feedback; rest; 2nd slide, etc. Ss in Group B (Delayed Reinforcement Group) and Group C (Control Group) were presented with the question; they wrote their answer; rest; 2nd slide, etc. Groups B and C had the same time interval for each slide as Group A but instead of feedback, they had an additional rest period. Thus, for each slide the experimental sequence for Session I was as follows:

| | | | | |
|---|---|---|---|---|
| Group A (Immediate) | Presentation Material | Write Answer | Feedback | Rest |
| Group B (Delayed) | " | " | Rest | Rest |
| Group C (Control) | " | " | " | " |

Each succeeding slide was exposed in an identical sequence.

At the end of the first experimental session for all groups, and also at the end of the second session for Group B (Delayed) and Group C (Control), Ss were given instructions designed to indicate that the experiment was over, as follows:

> Thank you. Please do not discuss this study with anyone, since we will be running subjects in other classes, during the next week. When we are finished gathering data, we will come in and report the results to you.

2nd Session. Twenty-four hours after Session 1, Groups B and C participated in the second session. Ss in Group B, Delayed Reinforcement Group, were instructed that they would be shown the same questions with information relative to the correct answer; they should look at each question carefully, but should not write the answer.

Ss were then given feedback in the identical forms and for an equivalent interval as that given to Group A, Immediate Reinforcement Group: rest; feedback for the 2nd question, etc. Ss in Group C, Control Group, were instructed that they would be shown the same questions and be asked to answer them again. They were presented with each question; wrote their answer; 2nd question, etc. Thus, for each slide the experimental sequence for the second session was as follows:

| | | |
|---|---|---|
| Group B (Delayed) | Feedback | Rest |
| Group C (Control) | Presentation Material | Write Answer |

3rd Session. Seven days after Session 1, Ss in all three groups were tested on the material. They were instructed that they would again be shown the same material and that they would be asked to answer each question. The questions were presented in the same form but in a randomly assigned order different from the original presentation. For all groups the procedure was as follows: Presentation of the material; write answer and turn it over; rest; 2nd question, etc. Thus, for each slide the experimental sequence for the third session was as follows:

| | | | |
|---|---|---|---|
| Groups A, B, C | Presentation Material | Write Answer | Rest |

The four experiments differed in the specific timing for each experimental session (see Appendix A). Other specific differences for each experiment are described below.

## Experiment I

Subjects were 75 undergraduate students, assigned to the three groups as follows: 29 in Group A, Immediate Reinforcement Group; 24 in Group B, Delayed Reinforcement Group; and 20 in Group C, Control Group.

Materials. Learning material consisted of thirty multiple-choice questions on discrete factual items generally relating to the social sciences (see Appendix B). Two criteria were used in the selection of items: 1) coverage of a wide range of topics in the social sciences; and 2) a fact unfamiliar to the average undergraduate student in psychology.

## Experiment II

Subjects were 127 undergraduate students, assigned to the three groups as follows: 67 in Group A, Immediate Reinforcement Group; 33 in Group B, Delayed Reinforcement Group; and 27 in Group C, Control Group.

Materials. Learning material consisted of eight multiple-choice questions with a nonsense syllable as the main word in the stem and a different nonsense syllable for each of the four alternatives. (See Appendix B). For each question the five nonsense syllables used had the same associative value (Glaze, 1928). On half of the items, the nonsense syllables were those of 0 per cent associative value; on the other half, 33 per cent associative value. Also, for each item, each nonsense syllable differed in its initial letter, vowel, and last letter.

## Experiment III

Subjects were 119 undergraduate students, assigned to the three groups as follows: 32 in Group A, Immediate Reinforcement Group; 60 in Group B, Delayed Reinforcement Group; and 27 in Group C, Control Group.

Materials. Learning material consisted of 14 items from which an inductive generalization, or principle, could be derived. (See Appendix B). In this experiment the material and the four alternatives were presented successively rather than on the same slide. For each item the subject was first shown a slide containing approximately

five written statements of facts. He was then shown a slide containing four principles, one of which followed from the facts presented. As in Experiments I and II, reinforcement was presented on one slide, including the original material, four alternatives, with the correct answer underlined.

Experiment IV

Subjects were 105 undergraduate students, assigned to the three groups as follows: 38 in Group A, Immediate Reinforcement Group; 40 in Group B, Delayed Reinforcement Group; and 27 in Group C, Control Group.

Materials. Learning material consisted of 13 items, essentially the same as the material in Experiment III. In this experiment reinforcement was presented by two 2" x 2" slides simultaneously: one, with the original material and four alternatives; the other with the feedback, which consisted of a cue directing the subject to the correct answer.

## RESULTS

### Experiment I

Analysis of the amount of learning was based on the individual subjects' difference scores from Session I, the original presentation of the material, to Session III, the final presentation of the material--i.e., the number correct on Session III minus the number correct on Session I. Analysis of these data by means of the *t* test showed the mean gains of both Group A, Immediate Reinforcement, and Group B, Delayed Reinforcement, to be significantly greater than that of the Control Group at less than the .0001 level of confidence (see Table 1). Thus, both the experimental groups showed a significant amount of learning.

Comparing Group A and Group B, the *t* test showed the mean gain of Group B, Delayed Reinforcement Group, to be significantly greater than that of Group A, Immediate Reinforcement, at less than the .005 level of confidence. Although both groups showed significant learning, the Delayed Reinforcement Group showed a significantly greater amount of learning than the Immediate Reinforcement Group.

### Experiment II

The measure of learning was again the individual subjects' difference scores from Session I to Session III. Analysis of these data by means of the *t* test indicated that both Group A, Immediate Reinforcement Group, and Group B, Delayed Reinforcement Group, showed significantly greater mean gains than the Control Group at less than the .0005 level of confidence. (See Table 2.) Comparison between Group A and Group B showed no significant difference. Thus, in this experiment both the Immediate and Delayed Reinforcement Groups gave evidence of learning, but there was no difference between these two groups in the amount of learning.

Table 1

Experiment I: Comparisons Between Groups: Individual Subjects' Difference Scores (Session III Minus Session I)

| Group | N | Mean | s.d. | t | p |
|---|---|---|---|---|---|
| A - Immed. | 29 | 9.069 | 3.371 | 8.93 | <.0001 |
| C - Control | 20 | -.10 | 1.834 | | |
| B - Delay | 24 | 13.583 | 2.519 | 14.23 | <.0001 |
| C - Control | 20 | -.10 | 1.834 | | |
| A - Immed. | 29 | 9.069 | 3.371 | 3.1921 | <.005 |
| B - Delay | 24 | 13.583 | 2.519 | | |

Table 2

Experiment II: Comparisons Between Groups: Individual Subjects' Difference Scores (Session III Minus Session I)

| Group | N | Mean | s.d. | t | p |
|---|---|---|---|---|---|
| A - Immed. | 67 | .7313 | 1.94 | 4.3847 | <.0005 |
| C - Control | 27 | .5556 | 1.09 | | |
| B - Delay | 33 | .9091 | 1.44 | 4.4793 | <.0005 |
| C - Control | 27 | .5556 | 1.09 | | |
| A - Immed. | 67 | .7313 | 1.94 | .51387 | >.25 |
| B - Delay | 33 | .9091 | 1.44 | | |

Experiment III

The measure of learning was the same as in experiments I and II, the individual subjects' difference scores from Session I to Session III. The amount of learning for the three groups was compared by means of the *t* test. These analyses indicate that both Group A and Group B showed significantly greater mean gains than the Control Group at less than the .0005 level of confidence (see Table 3). Comparison between Groups A and B showed that the mean gain of Group B, Delayed Reinforcement Group, was significantly greater than that of Group A, Immediate Reinforcement Group, at less than the .0005 level of confidence. In this experiment, as in Experiment I, both experimental groups showed significant learning, but the Delayed Reinforcement Group showed a significantly greater amount of learning than the Immediate Reinforcement Group.

Experiment IV

As in the preceding experiments the amount of learning was based on the individual subjects' difference scores from Session I to Session III. These data were analyzed by means of the *t* test, indicating that both Group A and Group B showed significantly greater mean gains than the Control Group (see Table 4). Comparison between Group A and Group B showed no significant difference. Thus, both the Immediate and Delayed Reinforcement Groups gave evidence of learning, but there was no difference between these two groups in the amount of learning.

Table 3

Experiment III: Comparisons Between Groups; Individual Subjects' Difference Scores (Session III Minus Session I)

| Group | N | Mean | s.d. | t | p |
|---|---|---|---|---|---|
| A - Immed. | 32 | 3.31 | 3.03 | 3.3390 | <.0005 |
| C - Control | 27 | 1.2592 | 1.56 | | |
| B - Delay | 60 | 5.75 | 2.86 | 9.4345 | <.0005 |
| C - Control | 27 | 1.2592 | 1.56 | | |
| A - Immed. | 32 | 3.31 | 3.03 | 3.7487 | <.0005 |
| B - Delay | 27 | 5.75 | 2.86 | | |

Table 4

Experiment IV: Comparisons Between Groups: Individual Subjects' Difference Scores (Session III Minus Session I)

| Group | N | Mean | s.d. | t | p |
|---|---|---|---|---|---|
| A - Immed. | 38 | 3.000 | 2.49 | 4.1684 | <.0005 |
| C - Control | 27 | .7778 | 1.80 | | |
| B - Delay | 40 | 2.900 | 2.89 | 3.6314 | <.0005 |
| C - Control | 27 | .7778 | 1.80 | | |
| A - Immed. | 38 | 3.00 | 2.49 | .1629 | Null |
| B - Delay | 40 | 2.900 | 2.89 | | |

## DISCUSSION

The principal concern in this series of experiments was to subject the principle of immediate reinforcement to a reasonably controlled test using both subjects and learning material similar to typical classroom situations. The results of four such experiments are almost completely contradictory to the view generally accepted by textbook writers in educational psychology, teaching machine programmers, and several learning theorists as well. In no case was immediate reinforcement superior to delayed reinforcement.

Surprisingly, immediate reinforcement was not superior even with the nonsense material, which was deliberately designed to mitigate against any advantage, or facilitating activity, during a delay. The items were designed as arbitrary associations only. However, the general framework of the experiment may have given the subjects a set to search for meaningful relationships. At least this seemed apparent from subjects' comments during and after the experiment. Subjects appeared to continue milling over the material, trying to find a key. If this were actually the case, such activity on the part of the subjects may have interfered with any advantage of immediate reinforcement and also rendered the subjects in a more receptive state for the delayed reinforcement on the following day. Thus, with subjects who were trying to make sense out of senseless material, immediate and delayed reinforcement were of approximately equal effectiveness. If somewhat similar nonsense material were presented merely as arbitrary associations to be memorized, it would seem less likely that subjects would seek some logical relationship, and we would then predict an advantage for immediate reinforcement over delayed reinforcement.

Not only do the experiments fail to confirm the superiority of immediate reinforcement, but two of the experiments indicate a significant reversal--i.e., delayed feedback is more effective than immediate. This superiority was predicted for Experiment III, using inductive problems. The hypothesis was that this type of problem, i.e., requiring the learner to draw a generalization from examples, using rather familiar, meaningful material of which he has an adequate symbolic repertoire, would be conducive to relevant mediating activity in the interval between response and reinforcement. If reinforcement in the form of complete feedback about correctness or incorrectness functions to preclude or dampen such activity, then a delay of reinforcement should be the most effective way of teaching. Results of Experiment III are quite consistent with this view.

Experiment I was not deliberately designed to optimize mediating activity. Even here delayed reinforcement was significantly superior to immediate reinforcement. However, conditions were more conducive for symbolic mediating activity than in the typical animal experiments. Here, both stimulus and response were in the form of symbols, of which the subject has a large repertoire. The factual items were phrased in words well within the common vocabulary of subjects and were in form quite similar to that used in tests. Our interpretation is that the delayed group indulged in such mediating activity, i.e., mulling over the question and alternatives, during the interval of delay; and that after such activity, the feedback was more effective.

Experiment IV was designed to promote mediating symbolic activity in both groups. Our prediction was that there would be no significant difference in learning. The inductive material was chosen to stimulate intervening symbolic activity, but this time reinforcement was changed from complete information to merely a cue or prompt.

The hypothesis was that the cue would stimulate the Immediate Group to indulge in the sort of mulling over behavior expected of the Delay Group. Results support this hypothesis.

Perhaps other explanations could account for the general superiority of the Delayed Group. Let us examine some alternatives:

(1) The Delayed Groups had an opportunity to look up answers or to communicate with subjects in the Immediate Group. The difficulty with this explanation is that the Control Group had the same opportunity in every experiment and in no case gave any evidence of learning.

(2) The Delayed Groups received feedback 24-hours closer to the final test than did the Immediate Groups, i.e., 6 days vs. 7 days. However, all published work on retention and forgetting indicate that, with the general type of material used, forgetting has reached, for all practical purposes, a temporary asymptote well before six days and shows no appreciable daily loss by the end of such a period.

(3) The third possibility is that the differences in procedure had differential effects on the motivation of the subjects. Although no objective measures were taken, casual observations indicated that this was indeed the case. Subjects in the Immediate Groups were enthusiastic, eagerly awaited each new answer, and gave audible groans and hurrahs when knowledge of results was presented. In contrast, the Delayed Groups, during the initial presentation appeared extremely bored after the first slide or two. Some subjects opened books and began to read between slide exposures; others used the time to write personal letters. During the second session the Delayed Groups gave polite attention but showed none of the exuberance of the Immediate Groups. These observations are consistent with most previous findings emphasizing the superiority of immediate reinforcement. However, they point to the conclusion that such

motivational differences should favor the Immediate Groups. Any such advantage was obviously overcome.

(4) A fourth possibility is that any differences between the Immediate and Delayed groups were simply the result of massed versus distributed practice. That is, the Immediate Group received massed practice on the first day while the Delayed Group had practice distributed over two days. Practice alone was controlled by the use of Group C, the Control Group, who actually had more practice in overtly writing the answers. Similarly, the Control Group had distributed exposure to the material.

A related objection is that it is not distributed practice or exposure alone but the combination of this with reinforcement that leads to more effective performance. There are two difficulties with this explanation. In all cases, the Immediate Group was given a rest period between the feedback for one slide and the presentation of the next slide. This interval was designed greater than that postulated in all theoretical approaches dealing with the perseveration and subsequent decaying of the neural trace. Furthermore, distribution over time is inherent in the notion of a delay of reinforcement. The reinforcement is distributed, or delayed, as compared to immediate reinforcement which is given on the heels of the response.

## Limitations

No principle as general as a statement of the optimal temporal interval of reinforcement for human learning can be proved by a limited set of experiments. The present study was limited to the following conditions: college student subjects, three specific forms of learning material, two types of reinforcers, comparison between only two temporal intervals, and the use of but one test for retention. To be valid, any broad generalization will demand a more extensive base of evidence.

However, the results of four independent experiments do point consistently toward the same implications. Therefore, we feel that the following recommendations may serve a useful purpose.

Some Implications for Education

In one sense these four experiments may be considered as miniature models of typical classroom activity. That is, the subjects were presented with learning material; they then made some sort of response, overt and probably implicit; and subsequently, reinforcement was given in the form of information relative to the correct answer. In this light, much of teaching may be construed as initiating learning situations and then administering reinforcement. Typical examples of administering reinforcement would include returning corrected examinations, replying to class questions, comments and grades on daily assignments. However, the teacher is also administering reinforcement in many other activities. Whenever a problem is posed in a demonstration or lecture, and some information relative to the answer given, the teacher is giving reinforcement. Thus, any valid conclusions to be drawn from the present study would have implications relevant to much of the teacher's activity.

The results of these experiments tend to question whether the teacher's role should be that of a prompt answer-giver and purveyor of final information. In effect, the experiments indicate that often the withholding of information leads to superior learning. They further indicate that the actual giving of the correct answer may serve to halt the very activity the teacher is trying to promote.

Contrariwise, the experiments suggest that a major role of the effecting teacher as a dispenser of reinforcement is to maintain relevant learning activity. Two means of doing this would follow directly from this study: delaying reinforcement; and giving a cue or prompt. Probably, if relevant learning activity is ongoing at a

fairly high rate, a delay of reinforcement is called for. On the other hand, where some relevant activity is ongoing, but is either diminishing or weak, a prompt or cue may well serve to strengthen it. In this light the teacher may be viewed as, first, a hypothesis instigator who initiates some active symbol manipulation on the part of the students. His next duty then is to effectively maintain this ongoing activity.

In any specific case the best way to reinforce in order to maintain such activity depends, in part, on the material, the learner, and the kind of reinforcement used. The experiments do offer some relatively specific suggestions for different types of situations.

1. If students can be instigated toward some thoughtful mulling over of the material, it is best to delay reinforcement in the form of correct answers. The optimal amount of delay probably depends upon how long relevant thought can be maintained otherwise.

2. Where conditions are not suitable for such thoughtful mulling over, as indicated above, it is probably best to use some form of immediate reinforcement. Unsuitable conditions could arise from:

   a. The use of highly unfamiliar material so that students have little or no store of relevant symbols to utilize.

   b. The use of rote or meaningless material--e.g., arbitrary associations such as names on maps, characters of the alphabet, etc.

   c. Students who are unable to engage in relevant symbolic activity because of lack of previous learning, retardation, motives incompatible with such activity, etc.

3. Where conditions are intermediate to (1) and (2) above, i.e., where symbolic activity is possible but not high in the hierarchy of probability, the use of partial information or cues may serve to stimulate and/or extend relevant thought. Such prompts or cues could be given immediately, delayed until a later time, or strung out sequentially to support relevant activity over a longer period of time.

One general conclusion the four experiments mutually and unequivocally point to is the following: Neither teacher nor school administrator can afford to be irrevocably committed to either immediate or delayed reinforcement as the one best method. To be more effective the teacher must vary the timing of reinforcement. Today's administrator should be cautious about planning a curriculum or investing in teaching materials committed solely to immediate reinforcement.

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# Appendix A

## Specific Temporal Intervals for Each of the Experiments

## TEMPORAL INTERVALS FOR EACH EXPERIMENT

**EXPERIMENT I: Factual Materials**

| Session | Group | Material | Write Answer | Feedback | Rest |
|---|---|---|---|---|---|
| 1 | A-Immediate | 15'' | 10'' | 10'' | 10'' |
| 1 | B-Delayed | 15'' | 10'' | | 10'' |
| 1 | C-Control | 15'' | 10'' | | 10'' |
| 2 | B-Delayed | | | 10'' | 10'' |
| 2 | C-Control | 15'' | 10'' | | |
| 3 | A-Immediate | 15'' | 10'' | | 10'' |
| 3 | B-Delayed | 15'' | 10'' | | 10'' |
| 3 | C-Control | 15'' | 10'' | | 10'' |

**EXPERIMENT II: Nonsense Material**

| Session | Group | Material | Write Answer | Feedback | Rest |
|---|---|---|---|---|---|
| 1 | A-Immediate | 10'' | 10'' | 20'' | 10'' |
| 1 | B-Delayed | 10'' | 10'' | | 10'' |
| 1 | C-Control | 10'' | 10'' | | 10'' |
| 2 | B-Delayed | | | 20'' | 10'' |
| 2 | C-Control | 20'' | 10'' | | |
| 3 | A-Immediate | 20'' | 10'' | | 10'' |
| 3 | B-Delayed | 20'' | 10'' | | 10'' |
| 3 | C-Control | 20'' | 10'' | | 10'' |

EXPERIMENT III: Inductive Material

| Session | Group | Material | Alternatives | Write Answer | Feedback | Rest |
|---|---|---|---|---|---|---|
| 1 | Immediate | 80'' | 20'' | 10'' | 40'' | 10'' |
| 1 | Delayed | 80'' | 20'' | 10'' | | 10'' |
| 1 | Control | 80'' | 20'' | 10'' | | 10'' |
| 2 | Delayed | | | | 40'' | 10'' |
| 2 | Control | 40'' | 40'' | 10'' | | |
| 3 | Immediate | 40'' | 20'' | 10'' | | 10'' |
| 3 | Delayed | 40'' | 20'' | 10'' | | 10'' |
| 3 | Control | 40'' | 20'' | 10'' | | 10'' |

EXPERIMENT IV: Inductive Material With Cues

| Session | Group | Material | Alternatives | Write Answer | Feedback | Rest |
|---|---|---|---|---|---|---|
| 1 | Immediate | 80'' | 20'' | 10'' | 40'' | 10'' |
| 1 | Delayed | 80'' | 20'' | 10'' | | 10'' |
| 1 | Control | 80'' | 20'' | 10'' | | 10'' |
| 2 | Delayed | | | | 40'' | 10'' |
| 2 | Control | 40'' | 40'' | 10'' | | |
| 3 | Immediate | 40'' | 20'' | 10'' | | 10'' |
| 3 | Delayed | 40'' | 20'' | 10'' | | 10'' |
| 3 | Control | 40'' | 20'' | 10'' | | 10'' |

# Appendix B

## Sample Learning Material for Each of the Experiments

## Experiment I: Sample Questions

1. The first American psychologist who seriously undertook the experimental study of animal behavior was
   a. James
   b. Thorndike
   c. Watson
   d. Hull

2. The number of words the average college student can recognize is about
   a. 50,000
   b. 100,000
   c. 250,000
   d. 500,000

3. The "Libido Theory" originated with which of the following men
   a. Eric Fromm
   b. Sigmund Freud
   c. Carl Jung
   d. B. F. Skinner

## Experiment II: Sample Questions

1. A TUJ is more attractive than a
   a. GOC
   b. DIH
   c. NAF
   d. XED

2. A KUX is an example of
   a. CEV
   b. DAH
   c. BIW
   d. FOY

3. ZON is lower than a
   a. PIB
   b. JEY
   c. KAH
   d. VUC

Experiments III and IV: Sample Questions

1. A robin, before picking up a worm, flies in short rapid bursts. An eagle flies in a slow circular pattern when it searches for prey. Crows stealing corn fly straight in at low level. Eels, gorillas, and ostriches do not fly.
   a. Smaller birds fly faster.
   b. Larger birds move their wings more slowly.
   c. Birds consume organisms.
   d. Birds eat organic material.

2. Monkeys chatter much of the time. Eagles are usually silent. Mother hens cluck a lot. At their first performance, novice actors are often unable to speak. Ants and snakes never cry aloud when after prey. Crows stop cawing when pursued by a hawk. When hound dogs follow a trail they bay loudly. Near a weasel, chipmunks never squeak. Whooping cranes make a louder noise than crocodiles. A lion roars louder than a shark.
   a. Fear inhibits vocalization.
   b. Excitement promotes vocalization.
   c. Birds vocalize more than insects.
   d. Lions vocalize more than crocodiles.

3. Led by girl friends in a convertible, two Central Frosh recently walked 50 miles in 18 hours. A Vassar coed covered the same distance in 15 hrs. followed by a bus load of sailors. A 10 yrs. old Boy Scout made the hike in 19 hrs. with his dog. Attorney General Kennedy walked it in 14 hrs. escorted by 12 FBI agents. Former Pres. Truman hiked the route in $12\frac{1}{2}$ hrs. after visiting Gen. MacArthur.
   a. Younger men walk faster.
   b. The larger the escort, the slower the walk.
   c. Younger men walk slower.
   d. The less the escort, the slower the walk.

"For Experiment IV, the following cues were used as reinforcement for the above questions:

1. What common behavior is shown by crows, eagles, and robins?
2. Look for a relation between some emotion and noise.
3. Rank the walkers by time and look for another characteristic which will also be ranked.